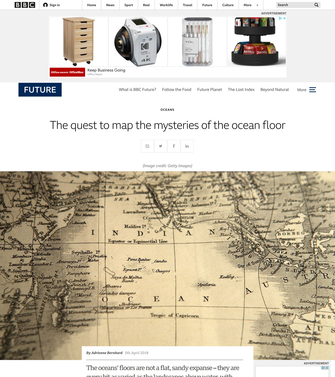
OCEANS

The quest to map the mysteries of the ocean floor



(Image credit: Getty Images)

By Adrienne Berard 5th April 2018

The oceans' floors are not a flat, sandy expanse – they are every bit as varied as the landscapes above water, with plunging valleys and huge mountains. Making a map of them has been a challenging task.

Geologists have charted mountain ranges and forests and desert tundras, environments the heaviest above, yet our planet's oceans remain largely unexplored. It's often said that we have a more complete understanding of the Moon or Mars than we do of our own seabed.

The sea's terrain plays a critical role in our ecosystem. Underwater crests and valleys influence currents and temperatures, which affect marine life and climate. The management of fisheries that feed millions relies on knowledge of underwater cables connect billions more to the Internet, seamounts provide protection against coastal hazards such as approaching hurricanes or tsunamis, and may even offer clues to the prehistoric movement of the earth's southern continents.

Far below the ocean's surface lie precious metals, rare earth elements, oil and diamonds – riches that have, until now, remained inaccessible to even the great intrepid of prospectors

In 2017, an international team of experts from around the world, united under the non-profit General Bathymetric Chart of the Oceans (GebCo), launched the first effort to create a comprehensive map of the world's oceans.

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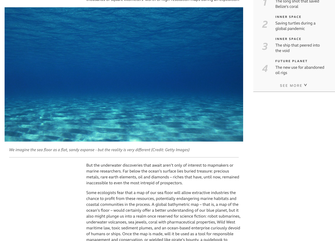
While the earliest oceanographers treated waters one painstaking knot at a time, recent advances in sater technology mean that a single ship can now provide thousands of square kilometers' worth of high-resolution maps during an expedition.



We imagine the sea floor as a flat, sandy expanse – but the reality is very different (Credit: Getty Images)

But the underwater discoveries that await aren't only of interest to mapmakers or marine researchers. Far below the ocean's surface lies buried treasure: precious metals, rare earth elements, oil and diamonds – riches that have, until now, remained inaccessible to even the most intrepid of prospectors.

Some ecologists fear that a map of our sea floor will allow extractive industries the ability to exploit the resources underneath without knowing the impact it will have on coastal communities in the process. A global bathymetric map – that is, a map of the ocean's floor – would certainly offer a better understanding of our blue planet, but it also might plunge us into a realm once reserved for science fiction: robot submarines, underwater volcanoes, sea jewels, coral with pharmaceutical properties, Wild West maritime law, toxic sediment plumes, and an ocean-bottom enterprise curiously devoid of humans or ships. Once the map is made, will it be used as a tool for responsible management and conservation, or entitled the polar's bounty, a goldmine to extraction and exploitation?

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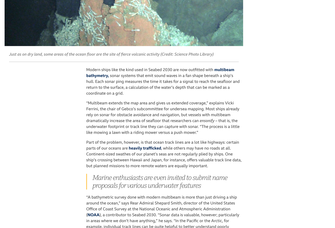
Only 15% of the Earth's ocean floor is mapped. Zoom in the middle of the Pacific in Google Earth, for example, and you'll find a representation of the ocean floor based on satellite and gravity-derived bathymetry: low-resolution, indirect, other inaccurate. Considering that we plotted our Solar System and charted the Martian grimoire, it's rather astonishing that no map of the seafloor exists. But the reason is simple: our planet's oceans are vast, deep, and largely impenetrable, and we haven't gone in the deep.

For centuries, charting the murky depths meant braving the high seas, dangling plumb lines over the side of a ship, then drawing basic contours on unexplored maps. Sailors etched soundings onto maps as early as the 16th Century, but no international standards for terminology or scale existed then, meaning early mapmakers relied rudimentary wayfaring tools, they were also confusing and contradictory.

It wasn't until the turn of the 20th Century, as era marked by soaring interest in the natural world, that a group of geographers gathered under the leadership of Prince Albert I of Monaco to produce the first international charts of the ocean floor (and eventually become GebCo). Albert was fascinated by the then relatively new science of oceanography, and commissioned four research yachts to survey the Mediterranean. More than 100 years later, GebCo and the **Nippon Foundation** formally announced the Seabed 2030 project, a ten-year initiative to map the ocean floor, using all the data gathered from vessels around the world – including soundings from three early expeditions.



Just as on dry land, some areas of the ocean floor are the site of fierce volcanic activity (Credit: Science Photo Library)

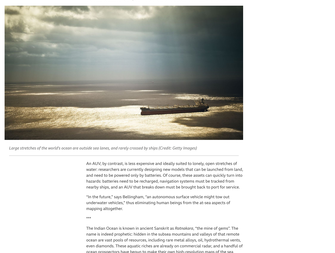
Modern ships like the kind used in Seabed 2030 are now outfitted with **multibeam echosounders**, which send sound waves in a fan-shape across the ocean surface to hull. Sailors can gauge how long it takes the sound waves to reach the seafloor and return to the surface, and use a calculation of the water's depth that can be marked as a coordinate on a grid.

"Multibeam extends the map area and gives us extended coverage," explains Vicki Ferrini, the chief of GebCo's subcommittee for undersea mapping. Most ships already rely on sonar for obstacle avoidance and navigation, but vessels with multibeam dramatically increase the area of seafloor that researchers can identify: that is, the underwater footprint or track line they can capture with sonar. "The process is a little like mowing a lawn with a riding mower versus a push mower."

Part of the problem, however, is that ocean floors can have a lot like highways: certain parts of our oceans **heavily trafficked**, while others may have no roads at all. Continent-sized swathes of our planet's seas are not regularly plied by ships. One ship's crossing between Hawaii and Japan, for instance, offers valuable track line data, but planned missions to more remote waters are equally important.

Marine enthusiasts are even invited to submit name proposals for various underwater features

"A bathymetric survey done with modern multibeam is more than just driving a ship around the ocean," says Rear Admiral Shepard Smith, director of the United States Office of Coast Survey at the National Oceanic and Atmospheric Administration (NOAA). Smith's agency, which is GebCo's US partner, coordinates ocean mapping in areas where we don't have anything. "We says 'I'm headed to the Arctic, for example, individual track lines can be quite helpful to better understand poorly mapped areas."



Though we have been laying cables across the ocean floor for over 150 years, much of the ocean floor is a mystery (Credit: Getty Images)

GebCo hopes to mitigate this problem by encouraging cargo ships, fishing boats and pleasure craft to participate in the project and transmit their data in real time, effectively crowdsourcing the underwater map. The organization also offers a "crank book" a technical reference manual on building bathymetric grids, which can help developing nations make use of shared expertise. Marine enthusiasts are even invited to submit name proposals for various underwater features – knolls, aprons, ridges, valleys, canyons, trenches, saddles, slits and sub-plains. Seabed 2030 has – by sending a letter to the International Hydrographic Organisation in Monaco.

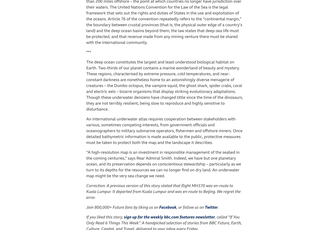
The actual map is assembled at the British Oceanographic Data Centre in the UK. Helen Snaith, the Global Centre lead for Seabed2030, notes that "everyone from fishermen to oceanographers to policy makers and the general public can access the current data" via a marine KO app.

Perhaps no single modern expedition reveals the complexity of deep-sea ocean mapping more strikingly than the search for the missing Malaysian Airlines Flight 370

Perhaps no single modern expedition reveals the complexity of deep-sea ocean mapping more strikingly than the search for the missing Malaysian Airlines Flight 370 (MH370). Investigators suspected that the plane, which vanished in 2014 en route to Beijing, crashed in a remote area of the Indian Ocean. The search was poorly mapped, however, that search teams had to do basic mapping of the search area. Seabed 2030 would draw up a more precise map with enough detail to aid future wreckage.

In fact, the search area was too deep to explore with ship-based mapping. In shallower water, sonar-equipped towboats trail behind a manned vessel, but the Indian Ocean's depth, monsoon climate and powerful currents made navigation of towed vehicles nearly impossible; instead, investigators dispatched a fleet of autonomous underwater vehicles, or AUVs.

Though underwater robotics is in its infancy, deep sea surveys have come to rely increasingly on submarines to scour the seabed for more detailed mapping. "There are many advantages to AUVs," explains James Bellingham, director of the Woods Hole Center for Marine Robotics in Massachusetts, USA. "They are faster, they provide higher-resolution data, and they can, including for bathymetry, fly close to uplifted features and provide more detailed information." Unlike ship-based surveys, AUV exploratory system costs several million dollars and requires trained operators to sort the data, because ships, by definition, float on the ocean's surface – not below it.



Large stretches of the world's ocean are outside sea lanes, and rarely crossed by ships (Credit: Getty Images)

An AUV, by contrast, is less expensive and ideally suited to lonely, open stretches of water: researchers are currently designing new models that can be launched from land, and can be recovered by hand by a single person. Because they are untethered to the mothership, batteries need to be recharged; navigation systems must be tracked from nearby ships, and an AUV that breaks down must be brought back to port for service.

"In the future," says Bellingham, "an autonomous surface vehicle might tow out underwater vehicles," thus eliminating human beings from the at-sea aspects of mapping altogether.

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The Indian Ocean is known in ancient Sanskrit as Ratnakara, "the mine of gems". The name is indeed prophetic: hidden in the subsea mountains and valleys of that remote ocean are vast pools of resources, including rare metal alloys, oil, hydrothermal vents, and diamonds. Some of the world's most valuable diamond mines are in Africa, and ocean prospectors have begun to make their own high-resolution maps of the sea floor. That data can be of value to researchers, Ferrini explains: oil, mineral and seismic companies might want to contribute dismissed, or lower-resolution, data to GebCo's map, thereby protecting their commercial interests while adding important information to the 2030 project.

Consider that De Beers Group, an international corporation and household name in diamond mining and retail, formed a partnership with the Namibian government over 20 years ago in pursuit of diamonds off the coast of that mineral-rich country. More recently, De Beers added to its road fleet several AUVs – part of a drill and coaster mining system that can scour the surface of the seafloor, loosen deep seabed sediment for rough diamonds and haul their cache hundreds of metres to the surface.

While shallow water mining for sand, gold, tin, and diamonds is a decades-old enterprise, commercial deep sea mining is a new industry. Its environmental impact yet unknown. Scientists predict habitat degradation, slow and uncertain recovery, toxic sediment plumes, underwater noise, chemical spills in transport, and species extinctions.

A De Beers spokesperson confirms that the company "does not mine in areas considered to have high diversity of marine life," and stated that, post-mining, "seabed recovery occurs naturally over a period of time and is assisted by the sediment that we return to the seabed."

This is a race to get a baseline understanding of our oceans, before we change it dramatically – James Bellingham

Still, the industry's economic incentives often outweigh environmental safety concerns. Deep sea mining is a growing field, with companies ranging from cell phones and EVs to rechargeable batteries, magnets, computer memory and fluorescent lighting, and terrestrial oil reserves are being swiftly depleted, making the switch to deep sea seeds an ever more tempting prospect. "This is a race," explains Bellingham. "A race to get a baseline understanding of our oceans, before we change it dramatically. We've lost that race already in the Arctic, and it's too late to see what we no longer survives."

Aside from the obvious effects of climate change, many of our shared waters have also become prey to urban ocean: seafloors riddled with pipelines, router cables and aquaculture, a trend that suggests we are all too eager to exploit our oceans before we properly understand them.

Map or no map, international marine laws currently restrict deep sea mining more than 200 miles offshore – the point at which countries no longer have jurisdiction over the waters and the seafloor underneath, according to the UN. It's a fragile framework that sets out the rights and duties of States in the use and exploitation of the oceans. Article 76 of the convention repeatedly refers to the "continental margin," the boundary between crustal provinces (that is, the physical ocean edge of a country's land) and the deep ocean basins beyond them; the law states that deep sea life must be protected, and that revenue made from any mining venture there must be shared with the international community.

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The deep ocean constitutes the largest and least understood biological habitat on Earth. Two-thirds of our planet contain a wonderland of beauty and mystery. These regions, characterized by extreme pressure, cold temperatures, and near-constant darkness are nonetheless home to an astonishing diverse menagerie of creatures – The Dumbo octopus, the vampire squid, the ghost shark, spider crabs, coral and sponges that have provided medicines for treating cancer and inflammation. Though these underwater denizens have changed little since the time of the dinosaurs, they are not terribly resilient, being slow to reproduce and highly sensitive to disturbance.

An international underwater atlas requires cooperation between stakeholders with various, sometimes competing interests, from government officials and oceanographers to military submarine operators, fishermen and offshore miners. Once detailed bathymetric information is made available to the public, protective measures must be taken to protect both the map and the landscape it describes.

"A high-resolution map is an investment in responsible management of the seabed in the coming centuries," says Rear Admiral Smith. Indeed, we have but one planetary ocean, and its ecosystem depends on conscientious stewardship – particularly as we turn to its depths for the resources we can no longer find on dry land. An underwater map might be the very sea change we need.

Correction: A previous version of this story stated that flight MH370 was en route to Kuala Lumpur. It departed from Kuala Lumpur and was en route to Beijing. We regret the error.

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